Name _____

RNA Synthesis Simulation

The code of heredity carried in the nucleotide sequence of the deoxyribonucleic acid (DNA) molecule directs the metabolic pathways of most living organisms. To convert the coded information present in the double-stranded DNA molecule into the workings of protoplasmic metabolism, the code must be transcribed from the DNA molecule to a single-stranded intermediate form, ribonucleic acid (RNA). An enzyme known as RNA polymerase catalyzes transcription by constructing a strand of RNA nucleotides that is complementary to a particular gene sequence in the DNA molecule. Three types of RNA exist in most systems:

- Ribosomal RNA (rRNA)
- Transfer RNA (tRNA)
- And Messenger RNA (mRNA).

All three types are transcribed in the same manner. Posttranscriptional modifications, however, determine in part the final location of each RNA molecule and its function within the cell. In this exercise you will construct an mRNA molecule that carries the genetic code for the assembly of proteins.

Assembly

Use the key in the table below to assist you in building an mRNA molecule.

Kit Component	***Part of DNA molecule***	***Quantity Needed***
Pink beads	Ribose sugar	24
Red beads	Phosphate group	24
Orange beads	Adenine (A)	6
Green beads	Guanine (G)	6
Blue beads	Cytosine (C)	6
Purple beads	Uracil (U)	6

To create your 24 nucleotides:

1. Attach a phosphate group (red bead) to the 5’ position of the ribose sugar (pink bead)
2. Now attach any one of the four nitrogenous bases (adenine-orange, guanine-green, cytosine-blue, uracil-purple) to the 1’ position of the same sugar.
3. Separate the 24 nucleotides you created into 4 groups according to their nitrogenous bases (orange, green, blue, purple)

The genetic code carried in the nucleotide sequence of the DNA molecule is transcribed to an RNA molecule by RNA polymerase, which recognizes certain areas rich in adenine-thymine (A-T) base pairs. At these areas, called promoter regions, the DNA strands separate and begin transcription or RNA synthesis. To start this process, follow the directions below:

4. Horizontally align the DNA template with the DNA sense strand at the top
5. Separate the two DNA strands by sliding the RNA polymerase between them.
    - Leave the DNA sense strand exposed and align the cut line of the template with the dotted line of the RNA polymerase (see Figure 2)
6. Line up the active site with the first white thymine (T) of the sense strand (AFTER the orange promoter region)

At the first DNA nucleotide after the promoter region, RNA polymerase temporarily attaches a complementary RNA nucleotide. During the copying process, RNA polymerase moves along the length of the DNA template from the 3' end toward the 5' end, bringing in successive complementary RNA nucleotides to the growing RNA single strand. The synthesis of the new RNA molecule is complete when RNA polymerase arrives at and recognizes a second area rich in A-T base pairs, where termination of transcription and subsequent release of both RNA polymerase and the complete RNA molecule are induced. To construct the mRNA molecule coded by the DNA sense strand, follow these directions:

7. Bring complementary RNA nucleotides to the active site of the RNA polymerase using the base pairing rules below

DNA nucleotides		RNA nucleotides
Adenine (A)	pairs with	Uracil (U)
Guanine (G)	pairs with	Cytosine (C)
Cytosine (C)	pairs with	Guanine (G)
Thymine (T)	pairs with	Adenine (A)

8. Move the RNA polymerase down the DNA template one nucleotide at a time, bringing the proper complementary RNA nucleotide to the active site
9. Align the RNA nucleotide antiparallel to the DNA sense strand
    - Note: Growth of the new RNA molecule occurs in a 5'-3' direction
10. Connect the phosphate group (red bead) of new RNA nucleotides to the 3' peg of the last ribose (pink bead) already on the RNA strand (see Figure 3)
    - RNA polymerase moves down the template one nucleotide at a time, while the growing RNA strand remains stationary beneath the DNA sense strand

Notice that the DNA double strands separate immediately in front of the advance RNA polymerase and rejoin immediately after its passage. Upon reaching the termination region, RNA polymerase releases from the DNA template, as does the new RNA strand. The completed RNA strand is an mRNA molecule that eventually carries the genetic code held within its nucleotide sequence to the ribosomes where protein synthesis occurs.

Finally, compare the mRNA molecule you created to the DNA molecule with which you started to answer the following questions.

1. How do the bases of the mRNA molecule compare to those of the sense strand of the DNA molecule?

2. How do the bases of the mRNA molecule compare to those of the nonsense strand of the DNA molecule?

3. What do you notice about the 5' and 3' ends of the mRNA molecule compared to the sense strand of the DNA molecule?

4. What similarities do you notice between RNA and DNA?

5. What differences do you notice between RNA and DNA?